STT CALIBRATION AND TRACKING

PANDA COLLABORATION MEETING

26.06.2019 I GABRIELA PÉREZ ANDRADE

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OVERVIEW

- The PANDA STT
- The HADES STS

- Testbeams at COSY
  - Raw data & calibration
  - Tracking

- Next steps

THE PANDA STT

Straws design

- 4224 straws in 19 axial and 8 stereo (±3°) layers
- 27µm Al-Mylar film, 1400 mm length, 10 mm diameter
- Ar/CO2 gas mixture at 1 bar overpressure
- Continuous data stream readout (~ 15GB/s)
- Charged particles will describe helical trajectories

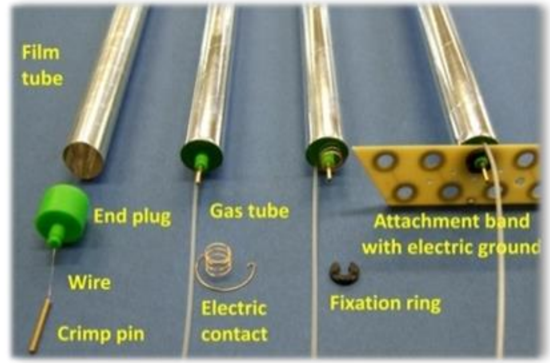
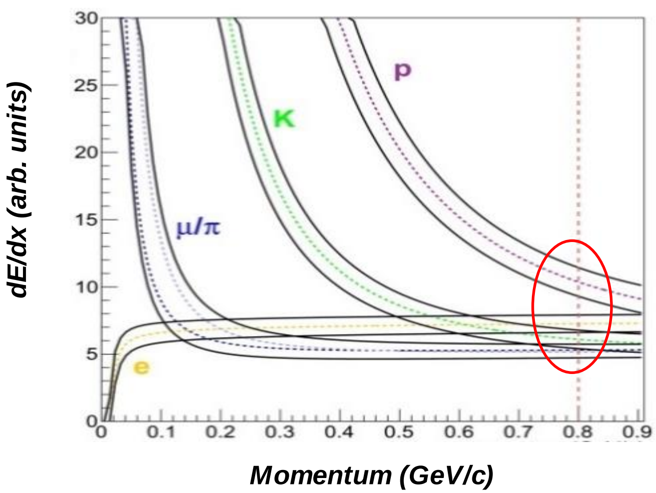
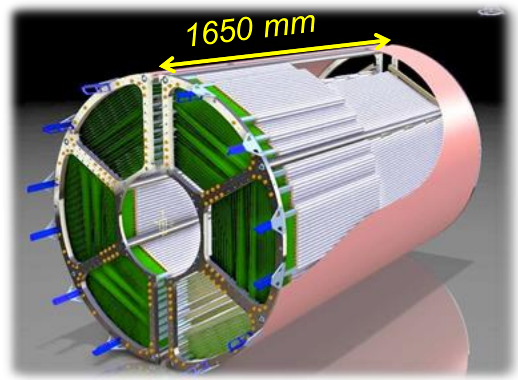
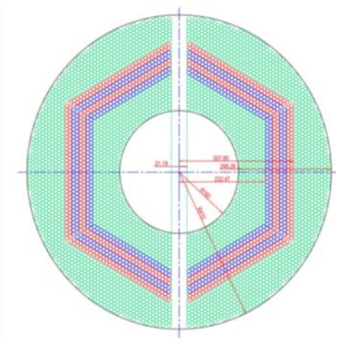


Figure. Straws components.







Figures. PANDA-STT layout

Detection method

- Charged particles traversing straws ionize gas molecules.
- Due to voltage difference between tube and wire, e^- drift towards wire
- Shortest distance from particle track to wire provided by earliest e^- to arrive.
- Drift time and charge readout used for tracking and PID (dE/dx)

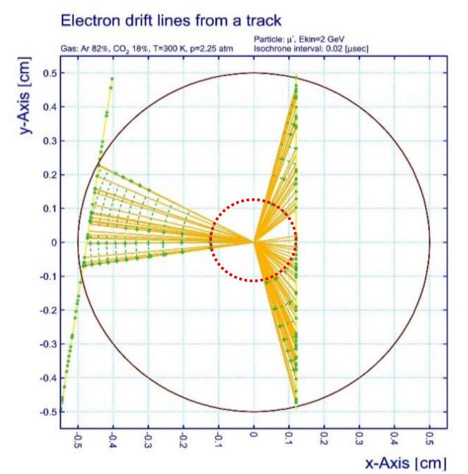
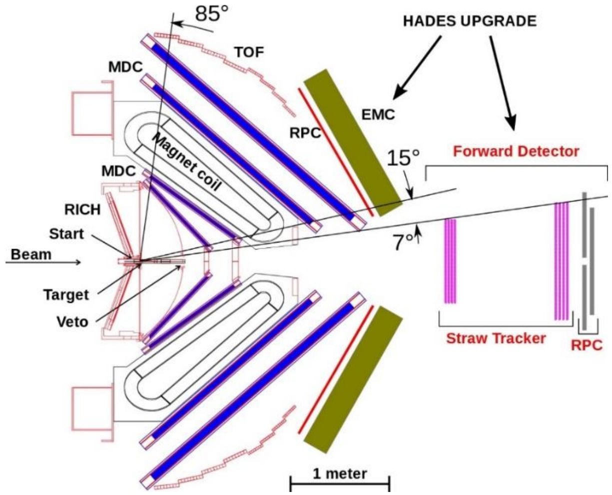


Figure. Electrons drift from particles path through the straw

THE HADES STS

For HADES upgrade (FAIR Phase 0)

- Straws detection principles same as PANDA STT
- No magnetic field at forward detector
- Triggered data tacking
- Forward Straw Tracker Stations :
  - STS1 (Jülich, assembly currently ongoing):
    - 640 channels, 20 modules
    - Double layers with: 90°,0°, 0°, 90°
  - STS2 (Krakow):
    - 896 channels, 28 modules
    - Double layers with: 0°, 90°, 45°, 45°
- Straw modules to be used in PANDA-FTS



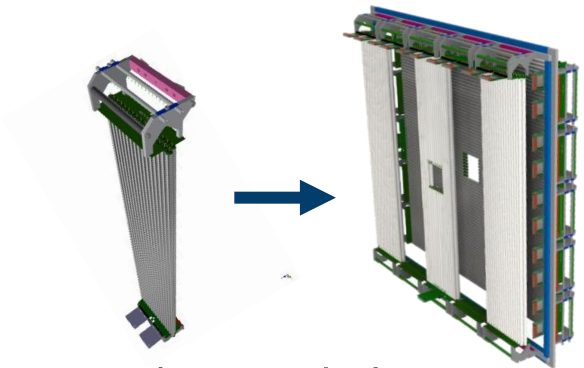


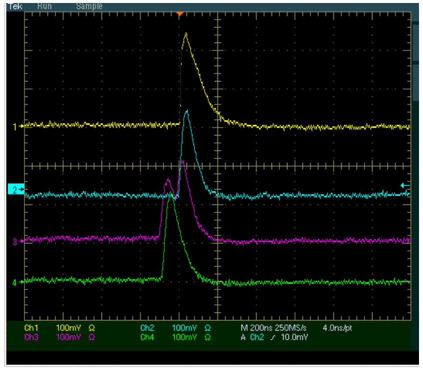
Figure. Example of straws arrangement (FT and STS case).

TESTBEAMS AT COSY (2016 & 2018)

Protons and Deuterons

- Momentum range: 0.5 - 3.0 GeV/c (~ 1 – 10 × MIP)
- Setups with 24 straws per layer:
  - Particle tracks with > 24 hits simmilar to PANDA STT case
- Ar/CO2 gas mixture
- Data in analysis stage.

One of the two straw test systems. Beam enters from the right.



Straw signals (in-beam)

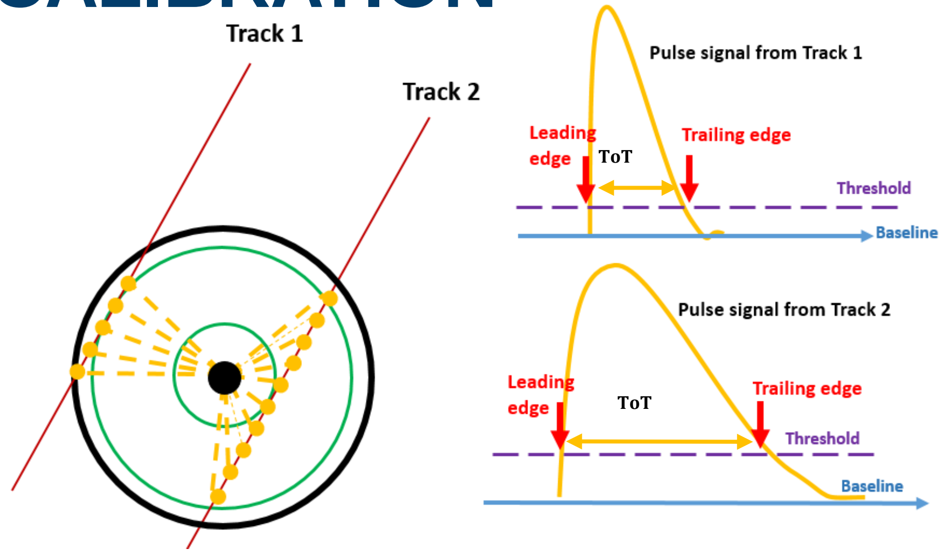
Current analysis addressing:

- Raw data calibration
- Tracking
- PID

For each beam case.

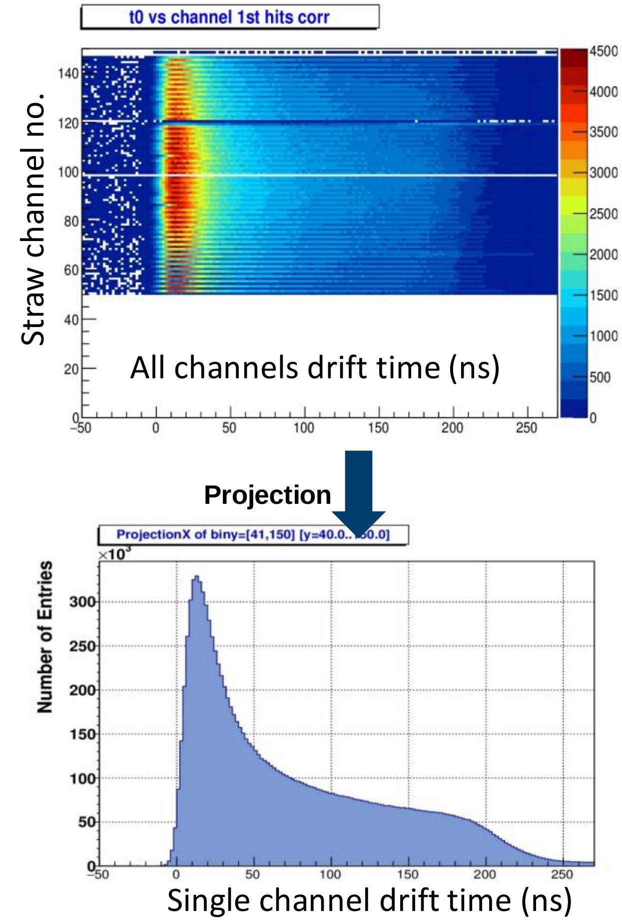
Figures. One of the two straw test systems.

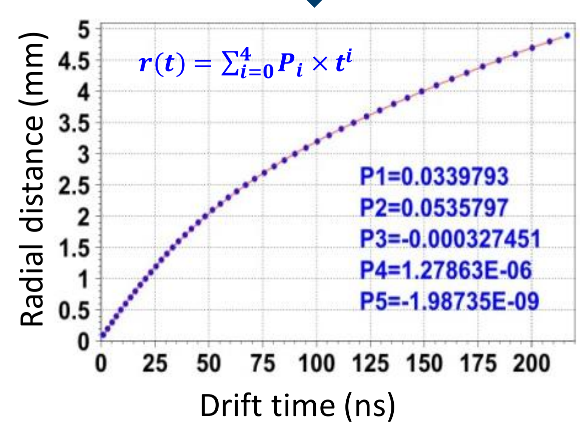
CALIBRATION



- Raw data: Signal times (t_{LE}, t_{TE}) and Channel number (i_{chan})
- Signal pulse width gives $ToT = t_{LE} - t_{TE}$
- From individual channel t_{LE} time distribution:
  - Minimum (t_0) from track close to wire
  - Specific channel t_0 offset correction
  - Maximum (t_{max}) from track close to the cathode wall
- Drift time spectra obtained by substracting t_0 from raw t_{LE}
- Radial distance from particle‘s path to wire (isochrone radii) parametrized as a polynomial function of the drift times:

$$r(t) = \sum P_i \times t^i$$





TRACKING

1. Pre-fit parameters: Position of fired wires
   - Obtain r_{iso} for each hit contained in the event with calibration $r(t)$
   - Define the residual distance:

$$r_{res} = r_{track} - r_{iso}$$

2. Track reconstruction using $\chi 2$- MINUIT fit to isochrones

$$\frac{\chi^2}{ndf} = \left(\frac{1}{n_{hits} - 2}\right) \sum_{n=1}^{n_{hits}} \frac{r^2_{res(nhits)}}{\sigma^2_{err(nhits)}}$$

   - n_{hits} , total number of hits
   - σ_{err} , uncertainty of the measurement in a straw in the radial direction
   - 2 are the parameters to be minimized

3. Iterative process to find better track parameters, *i.e.* Minimize $\chi 2$.

4. Outliers elimination rejection at each step.

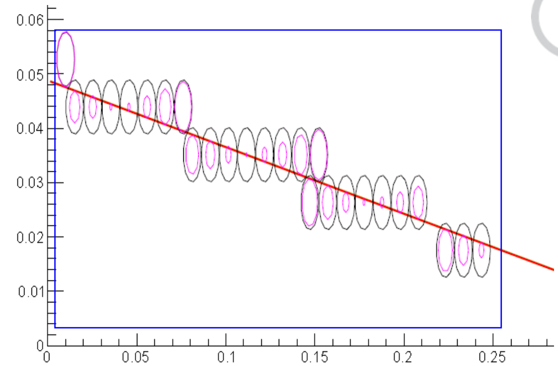
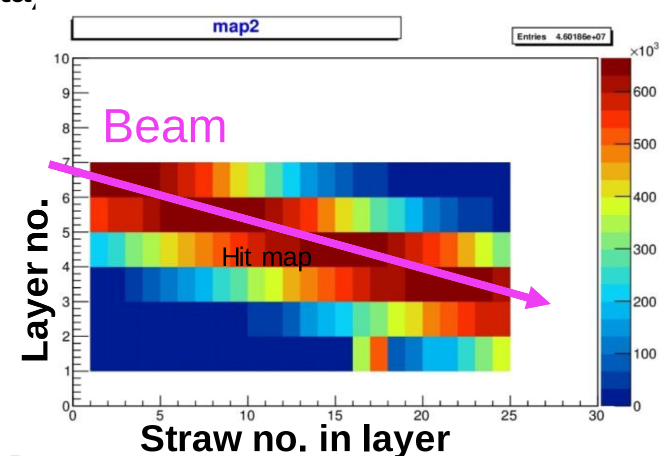
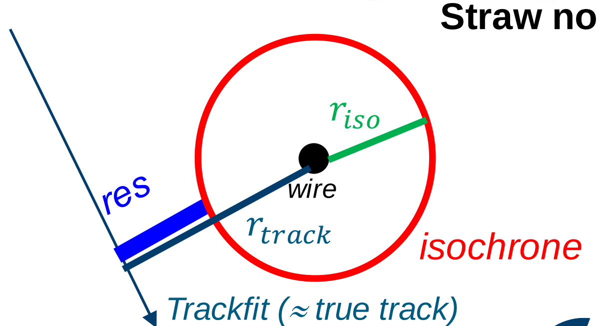
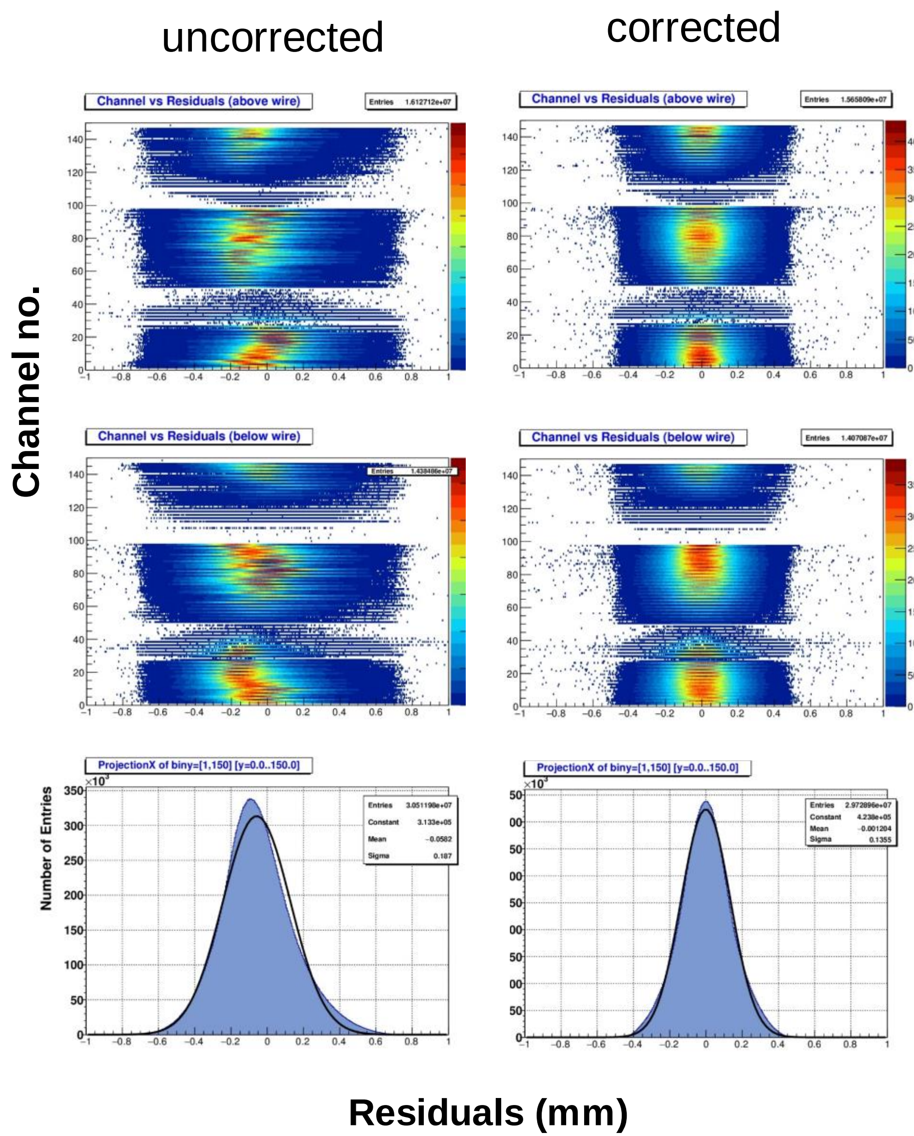


Figure. Track reconstruction (testbeam data)





TRACKING



4. Obtain residual distribution:
    - Ideally r_{res} = 0
    - Expected r_{res} values distributed around r_{res} = 0
5. Non-negligible shifts in r_{res} distribution
6. Find r_{mean} from fitted Gaussian to distribution.
7. Perform $r(t)$ correction:

$$r_{new} = r_{iso} + r_{mean}$$

- For above/below wire cases
- r_{mean} value is channel specific

4. Perform iteration process with r_{new} curve

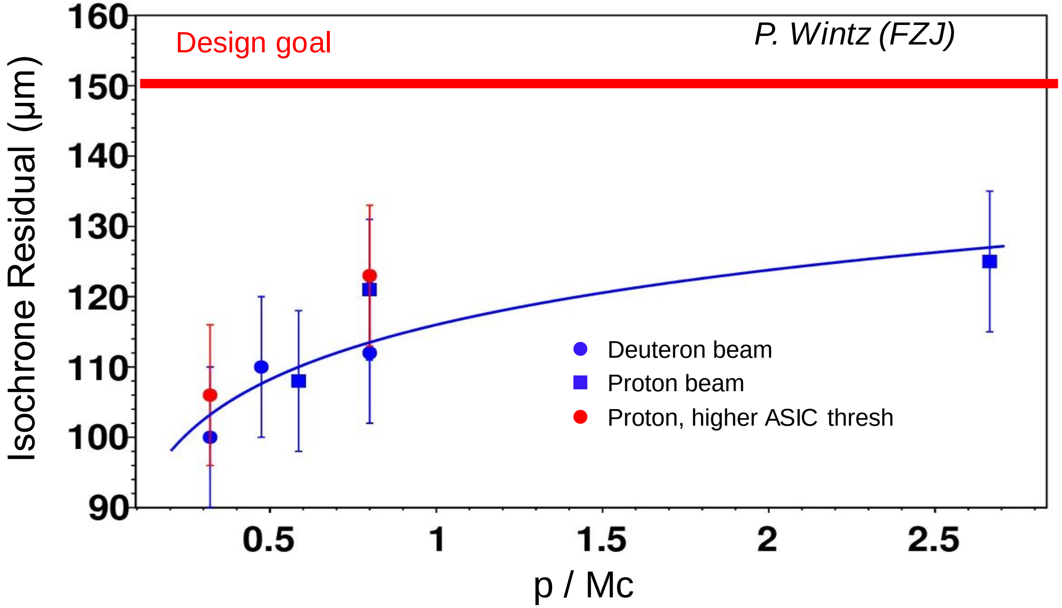
- ❑ Uncorrected : mean $= -58\mu m, \sigma = 187\ \mu m$
- ❑ Corrected : mean $= -1\ \mu m, \sigma = 135\ \mu m$

TESTBEAMS

Results

- Spatial resolution defined with σ value from residuals
  - 100-125 µm (design goal = 150 µm)

Current calibration and tracking methods are beam specific



NEXT STEPS

- Optimization of the time calibration, TOT calibration and tracking methods
- Investigate influence of dE/dx in isochrones calibration and tracking methods
- Determine which PID observable is the best

- Preparation of calibration and tracking with STS1 (HADES)
- Cosmic tests in Jülich foreseen for summer

THANK YOU!

Questions?

PID

1. Shifted raw ToT channel distributions before t0 offset correction.
2. ToT is drift time dependent ($1/\beta^2$), characterized by

$$ToT(t_{drift}) = \sum_{i=0}^{4} P_i \times t_{drift}^{i}$$

$$ToT(t_{drift} = 0) = ToT_{mean}$$

3. Truncate mean (~ 30 % highest hits) at each ToT distribution

$$ToT(t_{drift} = 0) = ToT_{trunc\ mean}$$

- Method needs t0 determination.

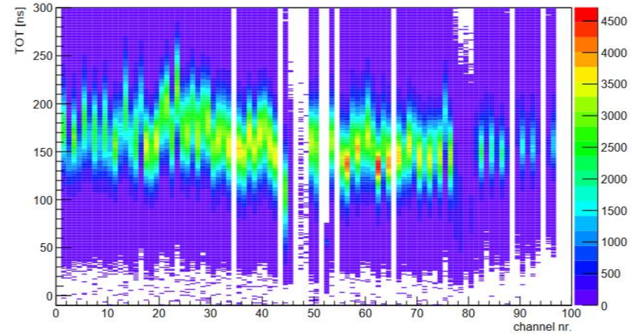
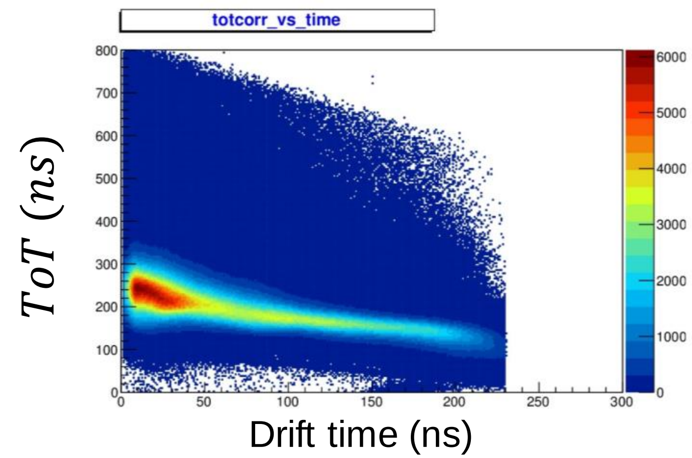
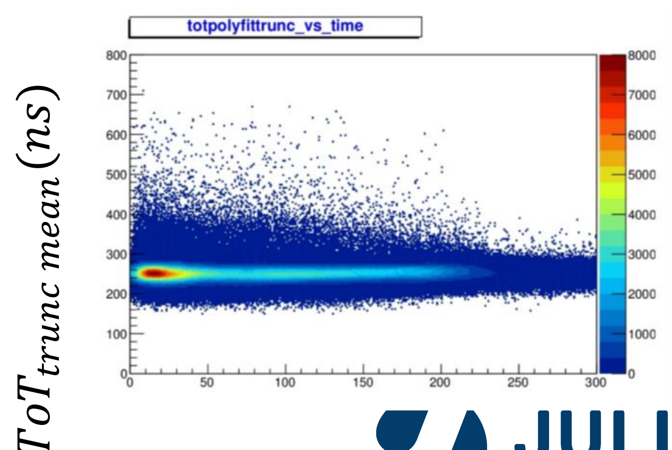
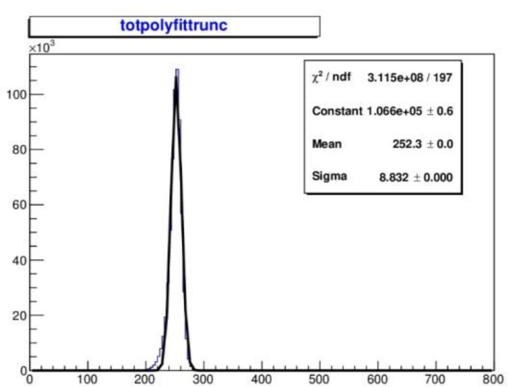


Figure. ToT raw data (ns) (All channels)





Drift time (ns)

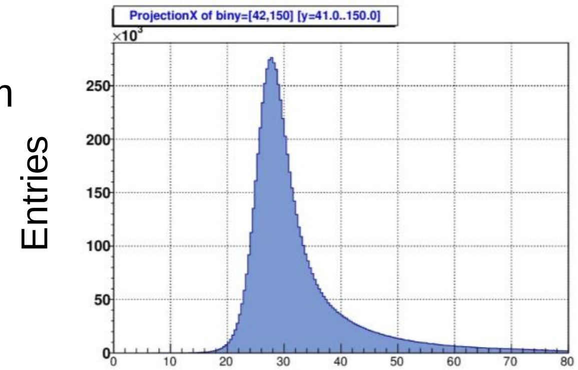


PID

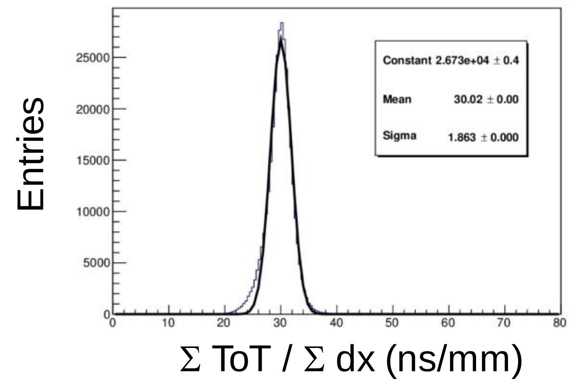
4. Consider ToT/dx as PID observable.

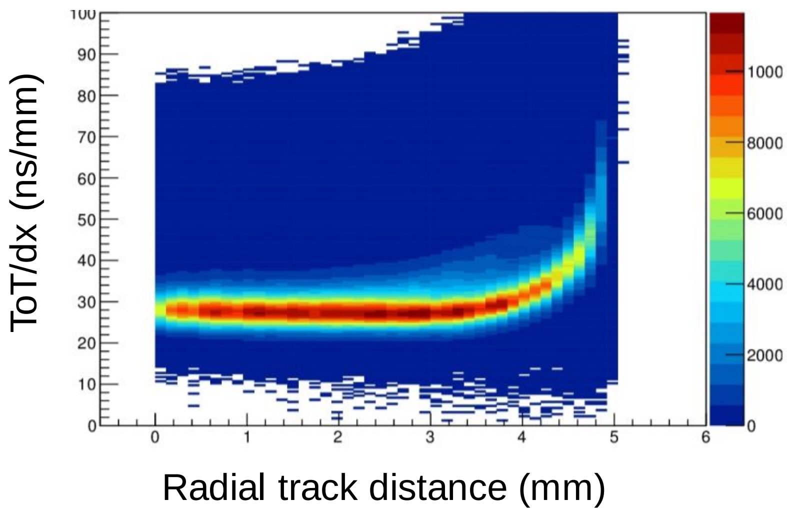
5. Perform mean truncation (~ 30 % highest hits)

- ToT/dx values distributed ~ constant over r = 0 – 4 mm
- No need of t0 determination.
- dx obtained by coarse tracking



Both PID variables (ToT and ToT/dx) are dE/dx dependent





TESTBEAMS

Results

- Spatial resolution defined with σ value from residuals
  - 100-125 µm (design goal = 150 µm)

- Separation power (PID)

$$S = \frac{\langle M_1 \rangle - \langle M_2 \rangle}{(\sigma_1 + \sigma_2)/2}$$

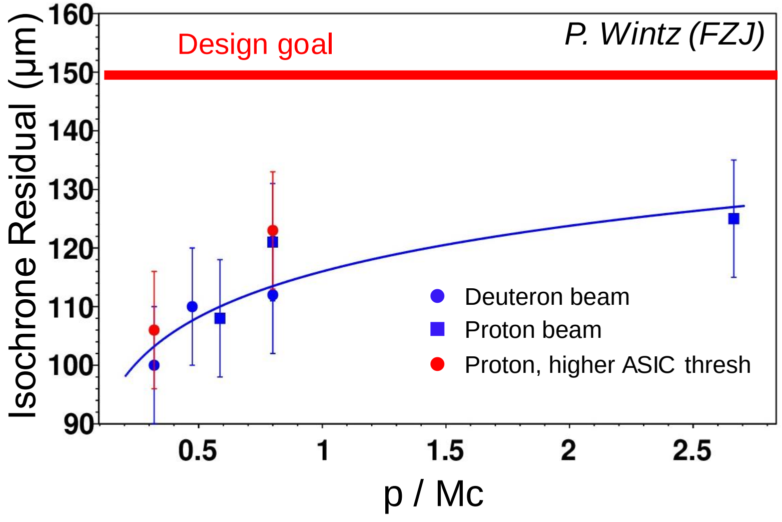
Where $\langle M_i \rangle = \langle ToT_\mathrm{i} \rangle$ or $\langle ToT/dx_i \rangle$

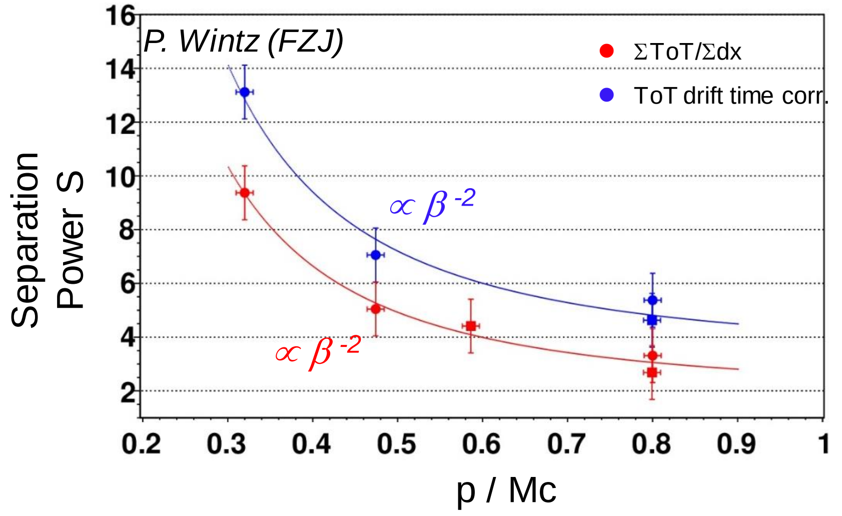
$i = 1,$ from chosen particle/momenta

$i = 2,$ reference from M.I.P. (2.5 $GeV/c\ protons$)

  - $1/\beta^2$ dependence
  - S ~ 4 - 12 in momentum range p < 1 GeV/c

Current calibration, tracking and PID methods are beam specific





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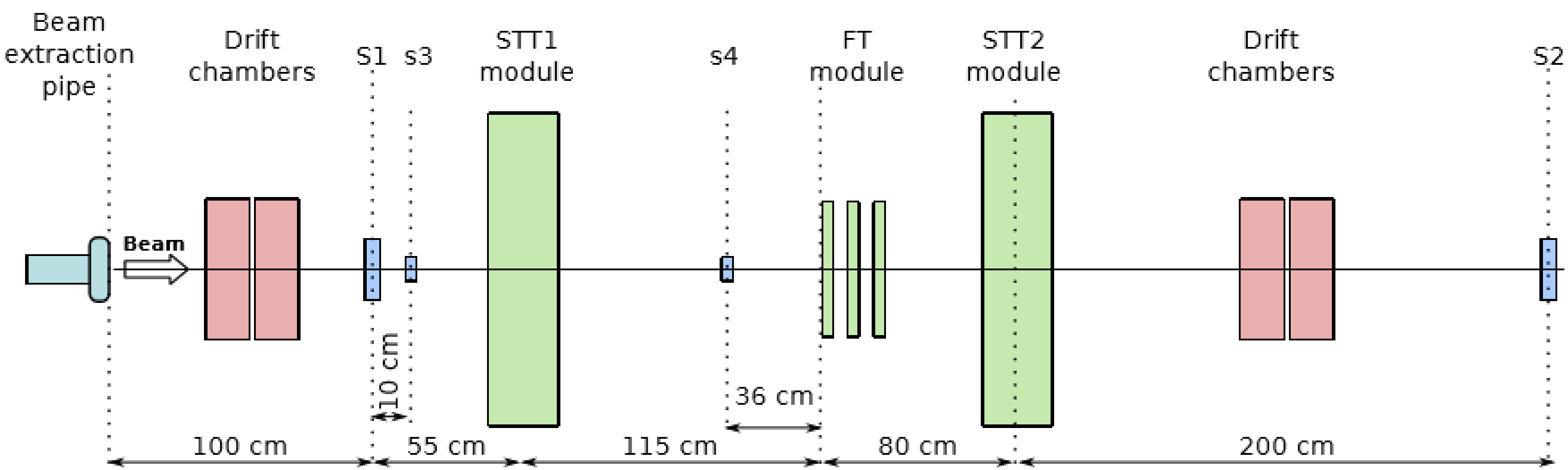

FIGURE 6.1: The schematic representation of the detector modules placement during the proton beam tests.